

The Potential for Alternative Fuel Use in Transportation Vehicles - Lessons from the U.S. Experience

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Alternative Fuel Vehicles in the U.S.

<u>Fuel</u>	<u>LD</u>	<u>HD</u>	<u>Total</u>
Propane	214,000	55,000	269,000
Natural Gas	89,000	21,000	110,000
Ethanol	48,000	20	48,020
Methanol	17,000	200	17,200
Electricity	10,000	400	10,400

Source: U.S. Energy Information Administration

Propane Vehicles

- Low Emissions
- Good Performance
- Cost Similar to Gasoline
- Few Typical Refueling Stations, Many Potential Places to Refuel
- Higher Vehicle Cost

GM Medium Duty Truck



Ford Club Wagon





Ford Crown Victoria

Natural Gas Vehicles



Ford F-150

- Very Low Emissions
- Good Performance
- Lower Cost Fuel
- Higher Vehicle Cost
- Limited Range, but Adequate for Most Applications
- Few Refueling Stations

Honda Civic GX



New Flyer D40 LF Bus



Ethanol Vehicles

- Low GHGs
- Less Reactive
- Subsidy Required to be Cost Competitive
- Few Refueling Stations but Numbers Increasing

Ford Taurus



Ford Ranger



Chrysler Minivan



Electric Vehicles

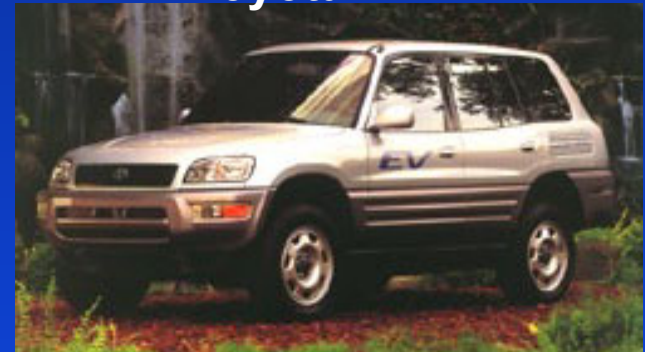
- Low Emissions
- Quiet
- At least 4% of new vehicles sold in California starting in 2003 must be EVs

Electricar EV Bus



- Expensive
- Limited Range

Toyota RAV4



Ford Ranger



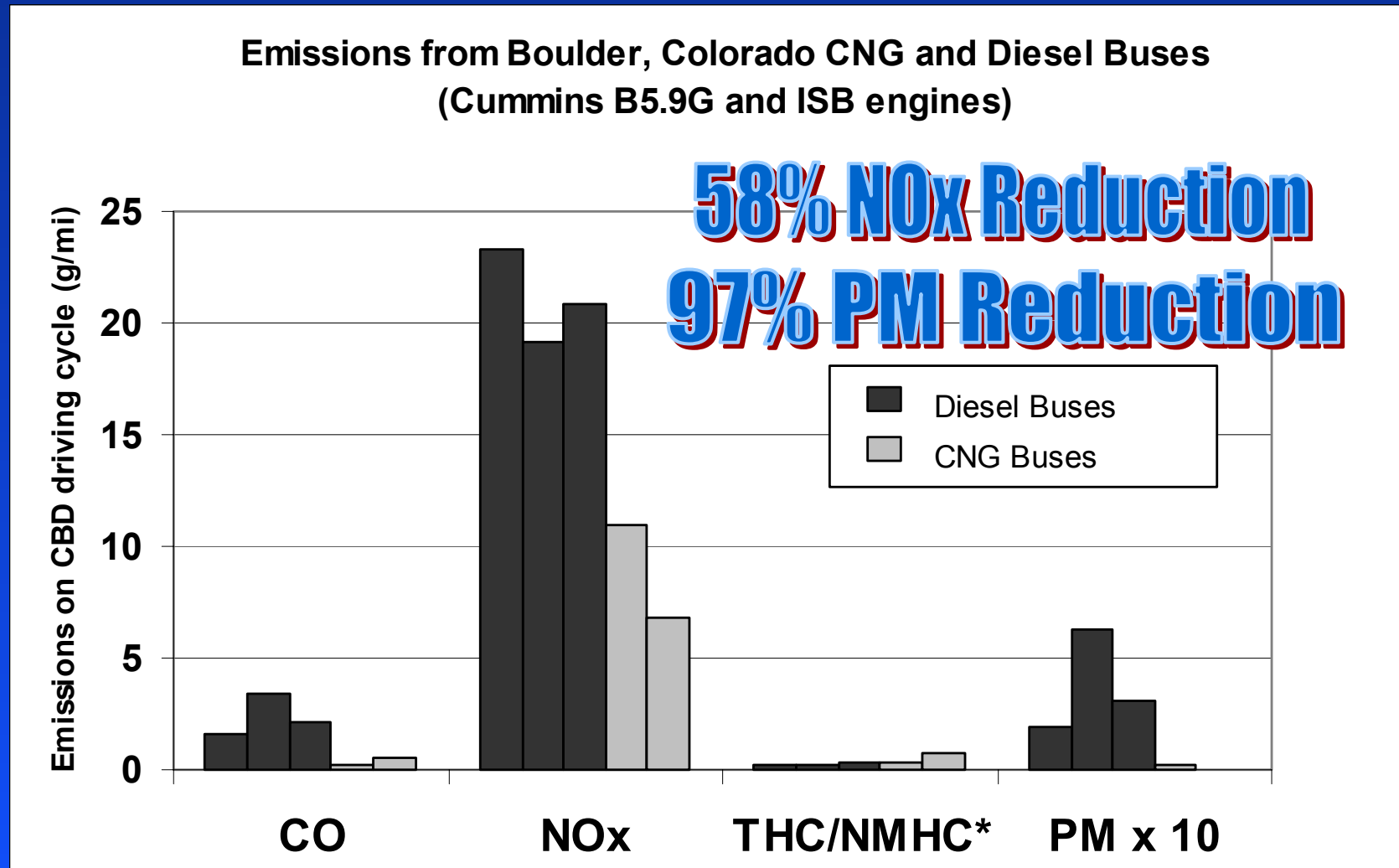
Why Use Natural Gas in Transportation Vehicles?

- Air Quality
 - ◆ Reduced PM
 - ◆ Reduced Ozone
 - ◆ Reduced Air Toxics
- Economics
 - ◆ Domestic Resource
 - ◆ Less Expensive
- Climate Change
 - ◆ Reduced GHG Emissions

2001 Honda GX - Cleanest IC Production Vehicle in the World?

- Achieved “Advanced Technology P-ZEV” certification from the California Air Resources Board
- Achieved California SULEV Emission Levels (0.01 g/mi NMOG, 1.0 CO, 0.02 NO_x, 0.01 PM) similar to Tier 2, Bin 2 (the level next to zero-emission vehicles)
- No evaporative emissions
- GHGs significantly lower than comparable gasoline vehicles (46% lower than the average compact car)

“Real-World” Emissions Reductions



Concerns About Diesel Exhaust

- PM can damage the lungs and exacerbate conditions such as asthma
- Some compounds within diesel exhaust are carcinogens
- Contributes to haze and deterioration of structures
- Contributes to ozone production

Natural Gas Buses in the U.S.

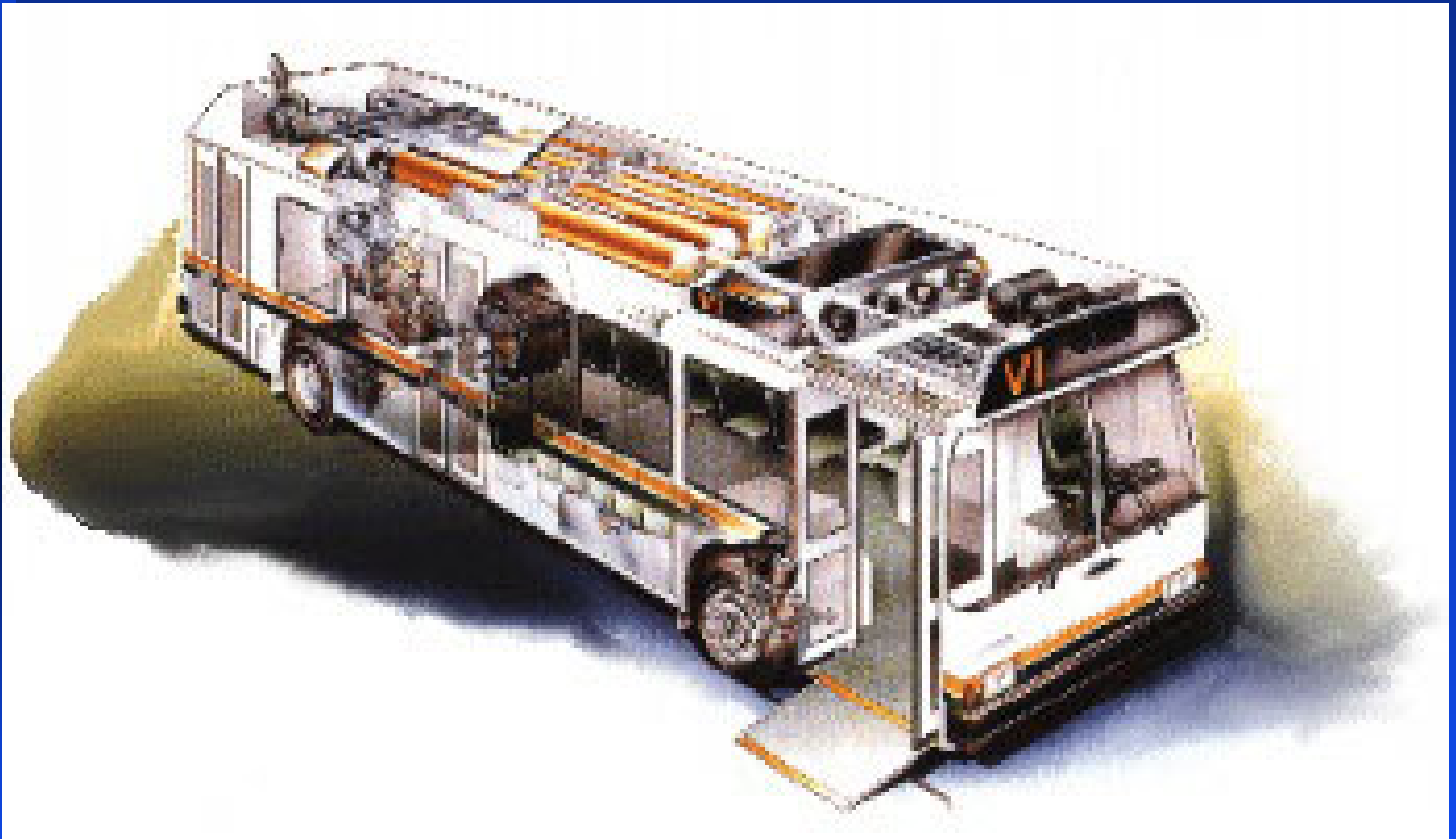
- 3500 CNG Buses currently in operation (7% of 50,000)
- 20-25% of all new transit buses on order are natural gas buses (CNG or LNG)
- All full-size transit bus manufacturers in the U.S. offer natural gas buses
- Natural gas buses are most in demand where air quality is an issue

Natural Gas Vehicle Storage

- Compressed Natural Gas (CNG)
 - ◆ Used most frequently now
 - ◆ Stores gas at 3000 to 3600 psi
 - ◆ Fuel system volume about 5 times that of diesel fuel
- Liquefied Natural Gas (LNG)
 - ◆ Stores NG as a liquid at around -240°F (-150°C)
 - ◆ Fuel system volume about twice that of diesel fuel

A Typical CNG Bus





Orion Bus Industries

LNG Buses



A Typical CNG Refueling Facility



An LNG and CNG Refueling Facility



Conversion of Diesel Engines to Spark-Ignited Natural Gas

- Advantages
 - ◆ Low PM emissions (90%+ reductions)
 - ◆ NOx emissions reduced by about half
 - ◆ Quiet operation
 - ◆ 100% use of natural gas
- Disadvantages
 - ◆ Lower efficiency (0-20% lower)
 - ◆ Extensive engine modifications

Conversion of Diesel Engines to Dual-Fuel Natural Gas

- Advantages
 - ◆ Little or no internal engine modifications
 - ◆ Reductions in PM and NOx emissions
- Disadvantages
 - ◆ Natural gas use dependent on driving cycle (no use at idle)
 - ◆ Emissions benefits less than spark-ignited engines though still significant

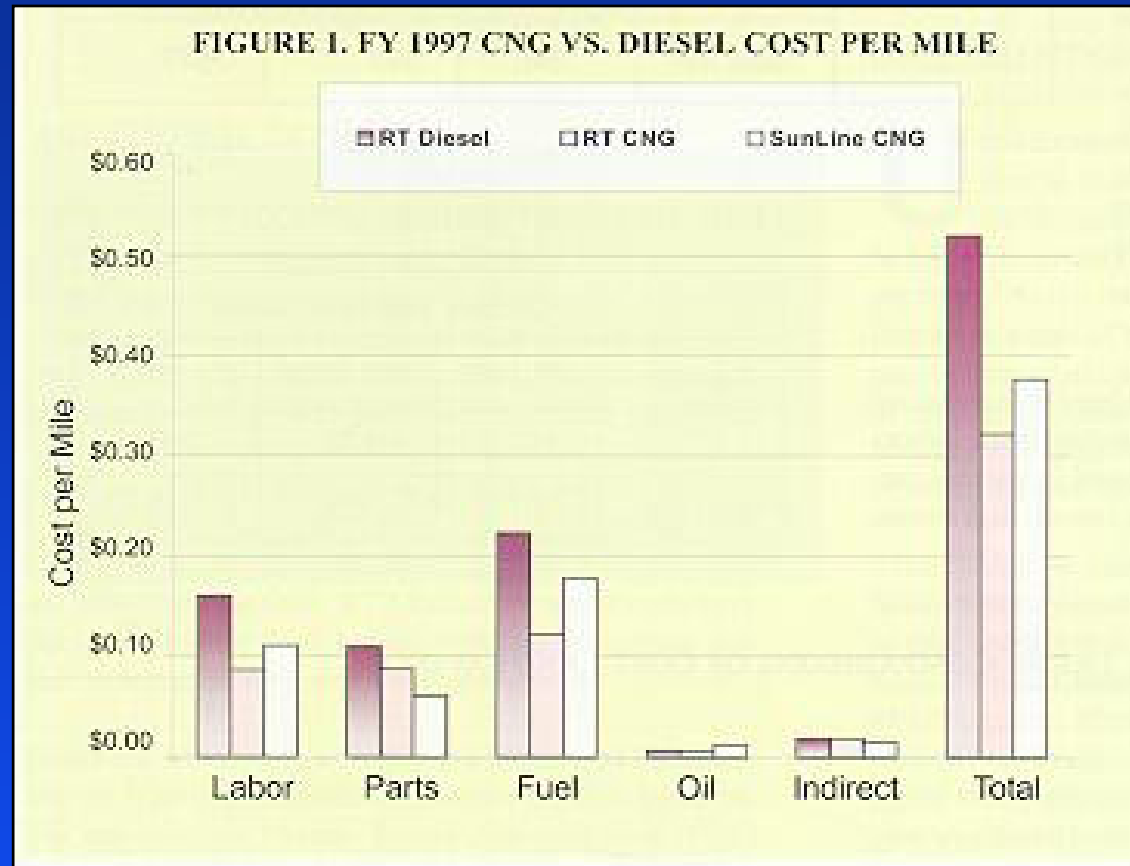
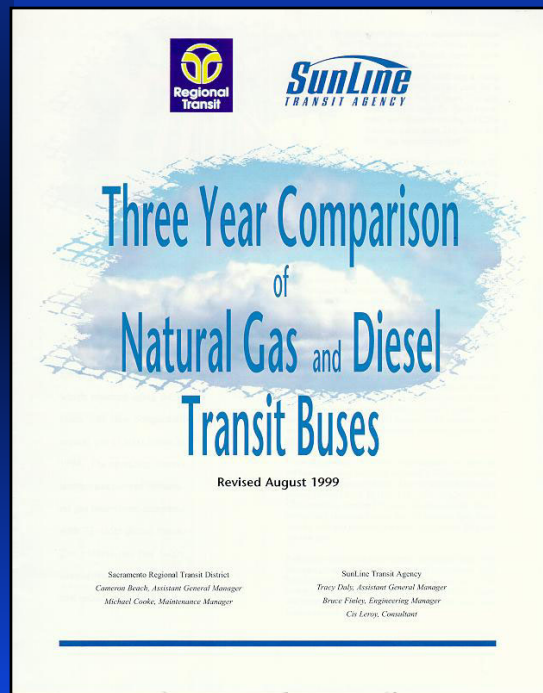
Changes to Fleet Operations for NGVs

- Training
 - ◆ Drivers
 - ◆ Maintenance Staff
 - ◆ The Public
- Facility Modifications
 - ◆ Storage and Maintenance
 - ◆ Refueling Facility (if put on-site)

Financial Considerations

- NG Buses Cost More
 - ◆ 10% to 20% more than conventional diesel
- Refueling Facilities More Expensive
- Fuel Costs are Reduced
- Life-Cycle Costs are Lower Without Accounting for Public Health Benefits

Sunline Transit Economic Results



Typical Reactions to Natural Gas Buses

- Public Notices Lack of Smoke and Smell, and Reduced Noise
- Mechanics Report Buses Cleaner to Work On
- Drivers Tend to Accept Quickly

A Path to a Cleaner and More Efficient Future

- Use natural gas now
- Phase-in new technologies
 - ◆ advanced emission controls
 - ◆ hybrid powertrains
 - ◆ fuel cells

Benefits of this Pathway

- Diversification of Energy Resources
- Improved Air Quality
- Greenhouse Gas Reductions
- Improved Balance of Trade (for those countries without significant oil resources)

Closing Remarks

- Natural Gas, Propane, and Ethanol Vehicles all have the potential to reduce emissions and displace oil.
- Renewable Fuels such as Ethanol have great potential to reduce greenhouse gases.
- The emission benefits of using alternative fuel vehicles are maximized by using dedicated vehicles instead of dual-fuel or bi-fuel vehicles.

Closing Remarks (con't)

- Natural Gas Buses Provide Several Benefits:
 - ◆ Proven Technology
 - ◆ Available Now
 - ◆ Domestic Fuel Resource
 - ◆ Improved Air Quality
 - ◆ Lower GHG Emissions

Closing Remarks (con't)

- Repowering buses with dedicated natural gas engines is preferable to spark-ignition or dual-fuel conversions.
- A “systems” approach is required to implement natural gas vehicles that includes:
 - ◆ Adequate refueling facilities
 - ◆ Training of drivers, mechanics, and other personnel
 - ◆ Public education about natural gas vehicles

Sources of Additional Information

- United States Department of Energy
 - ◆ www.ott.doe.gov
 - ◆ www.ccities.doe.gov
 - ◆ www.fleets.doe.gov
- Bluebird Bus Corporation (www.blue-bird.com)
- Cummins Engine Co. (www.cummins.com)
- DDC Engine Co. (www.detroitdiesel.com)
- John Deere Engine Co. (deere.com)